

JUNE 30, 1970

Statement of

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Administrator

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Committee on Aeronautical and Space Sciences  
United States Senate

Mr. Chairman and Members of the Committee:

We appreciate this opportunity to review with you the results of our investigations of the Apollo 13 accident and the steps NASA will take in light of the investigations before launching Apollo 14 to the moon.

In our appearance before the Committee on April 24, 1970, Apollo Program Director Dr. Rocco Petrone, Mission Director Glynn Lunney, and Astronauts Jim Lovell and Jack Swigert reported to you our understanding as of that time of the events leading to the accident and the subsequent operations which brought the Astronauts safely back to earth. At the same hearing, I reported to you the actions Dr. Low and I had taken to assure a prompt, thorough, and objective investigation of the accident. These included:

- (1) the establishment of the Apollo 13 Review Board, with Mr. Edgar M. Cortright, Director of the Langley Research Center, as Chairman,
- (2) the instruction to NASA's Aerospace Safety Advisory Panel to review the procedures and findings of the Apollo 13 Review Board and to submit its independent report within 10 days of the Review Board's report, and
- (3) the instruction to Mr. Dale Myers, NASA's Associate Administrator for Manned Space Flight, to provide necessary support to the Apollo 13 Review Board and to make recommendations, also within 10 days of the Review Board's report, on plans for eliminating the problems encountered in Apollo 13 in order to proceed with Apollo 14 and future manned space missions.

Today we are here to review with you the results of these actions and the resulting future program actions which Dr. Low and I are now taking to preclude a recurrence of such accidents and to move ahead with the Nation's manned space flight program. In summary:

--The report of the Apollo 13 Review Board was presented to us by Mr. Cortright on June 15 and made available to the Committee on the same day. Dr. Low and I have now had an opportunity to study the report in detail and to review carefully its recommendations. In our view it is an excellent report based on a thorough and objective investigation and highly competent analysis. It clearly pinpoints the causes of the Apollo 13 accident and sets forth a comprehensive set of recommendations to guide our efforts to prevent the occurrence of similar accidents in the future.

--The Aerospace Safety Advisory Panel submitted its report to NASA management at a meeting in Washington on June 25, 1970. With your permission, Mr. Chairman, I would like to place its report which is in the form of a letter from its Chairman, Dr. Charles D. Harrington, in the record.

Dr. Harrington is here this morning to respond to any questions you may have. At this point I would like to read the key portions of his letter report summarizing the Safety Panel's appraisal of the job done by the Apollo 13 Review Board:

"The Panel found that the Board's procedures and scope of inquiry proved effective in their task. The Review Board has performed a thorough and technically competent analysis in the reconstruction of the factors contributing

to the Apollo 13 abort. We found no evidence and no reason to doubt the technical validity of their determination and findings."

This independent evaluation provides substantial additional confidence to Dr. Low and me that our favorable appraisal of the report is correct.

--Mr. Myers, Dr. Petrone, and the Office of Manned Space Flight have also completed extensive experiments, tests, studies, reviews, redesign work and program rescheduling activities, and have presented recommendations on the required corrective measures and program adaptations. Last Thursday Dr. Low and I held an extensive review at which Mr. Myers, Dr. Petrone, Mr. McDivitt and other officials of the Apollo program discussed in detail the technical problems and alternatives with the senior officials of NASA. Also present were Mr. Cortright and members of the Review Board, Dr. Harrington and members of the Aerospace Safety Advisory Panel, Mr. William A. Anders, Executive Secretary of the National Aeronautics and Space Council, and the Directors of NASA's Manned Space Flight Centers: Dr. Robert R. Gilruth, Dr. Kurt H. Debus, and Dr. Eberhard Rees. Based on the discussions at this review and at follow up meetings extending over the next two days, Mr. Myers has formally

submitted to me with his endorsement the final recommendations of Dr. Petrone, the Apollo Program Director. These are embodied in Dr. Petrone's memorandum to me of June 27, 1970, which has been made available to the Committee, and which I would like to place in this record with your permission, Mr. Chairman.

On the basis of the reports and recommendations before us and detailed discussions with responsible and knowledgeable experts in NASA, Dr. Low and I have approved the following actions to implement the recommendations of the Apollo 13 Review Board and to carry out the steps recommended by Dr. Petrone and Mr. Myers to prepare for the Apollo 14 mission. In summary these actions are:

First, the recommendations of the Apollo 13 Review Board will be implemented before the Apollo 14 mission is approved for launch. This will require postponing the launch date to no earlier than January 31, 1971. Command Service Module systems will be modified along the recommended lines to eliminate potential combustion hazards in high pressure oxygen of the type revealed by the Apollo 13 accident. Unsealed fan motors will be removed from the oxygen tanks

and an additional oxygen tank added to the Service Module of Apollo 14. Electrical wiring within high pressure oxygen systems which might provide an ignition spark if damaged will be limited to stainless steel sheathed wires. Teflon, aluminum, and other potentially reactive materials in the presence of high pressure oxygen will be used as little as possible and kept away from possible ignition sources. For example, the quantity probe will be stainless steel instead of aluminum and the fuel cell oxygen supply valve which now has Teflon-insulated wires in high pressure oxygen will be redesigned to eliminate this hazard. Warning Systems onboard the spacecraft and at Mission Control will be modified consistent with the Board's recommendations to provide more immediate and visible warnings of system anomalies. A comprehensive review of spacecraft emergency equipment and procedures and use of Command Service Modules and Lunar Modules in "lifeboat" modes is now underway at the Manned Spacecraft Center in Houston. Dr. Petrone will outline for you the specific actions we plan to take in response to the first six recommendations of the Board, and Mr. Myers will discuss his specific plans for critically reassessing all

Apollo spacecraft subsystems in response to recommendation No. 9 of the Board.

Secondly, the Associate Administrators in charge of the Offices of Space Science and Applications, Manned Space Flight, and Advanced Research and Technology, have been directed to review the Apollo 13 Review Board Report to apply throughout NASA the lessons learned in their areas of responsibility. They have been instructed to take action with respect to recommendation No. 6 (concerning anomalies in critical subsystems prior to flight), recommendation No. 7 (calling for a thorough re-examination of all spacecraft, launch vehicle and ground systems which contain strong oxidizers to evaluate potential hazards) and recommendation No. 9 (concerning the design, manufacture, test and operation of spacecraft subsystems). I have requested a written report by August 25 on their assessment and the actions taken or proposed.

In addition, we will take steps to disseminate widely throughout industry and the technical community the lessons of Apollo 13 to prevent recurrences in other areas. You might be interested to know in this connection that I have

forwarded to Academician Keldysh of the Soviet Academy of Sciences a copy of the complete Apollo 13 Review Board Report so that lessons which might be learned from our accident can be applied to prevent a similar hazard to Soviet Cosmonauts.

Third, the Aerospace Safety Research and Data Institute (ASRDI) at the NASA Lewis Research Center has been directed to conduct additional research on materials compatibility, ignition, and combustion at various G levels, and on the characteristics of supercritical fluids, as recommended by the Apollo 13 Review Board. This will expand a review already begun by ASRDI on oxygen handling in aerospace programs. In this effort, the Lewis Research Center will be supported by other elements of the NASA organization. This research will be of direct long-term benefit to NASA in carrying out its future programs, and will help other sectors of the economy.

Fourth, I have requested that the Aerospace Safety Advisory Panel conduct a review of the management processes utilized by NASA in implementing the recommendations of the Apollo 13 Review Board and report to me their views no later than the Apollo 14 Flight Readiness Review. This will again



give us the benefit of the Panel's valuable independent insight when future decisions are made. I have also asked Mr. Cortright to reconvene the Apollo 13 Review Board later this year, as he suggested, to review the results of continuing tests to determine whether any modifications to the Board's findings, determinations, or recommendations are necessary in light of additional evidence which may become available.

The assessment of the Office of Manned Space Flight, in which Dr. Low and I concur, is that the reasonable time required for the design, fabrication, and qualification testing of the modifications to the Apollo system we have determined to be necessary, and for the other actions outlined above which must be taken before the next Apollo mission, will permit us to launch Apollo 14 to the Fra Mauro region of the moon at the January 31, 1971 launch opportunity. This will also move the planned launch date for Apollo 15 several months to July or August 1971, maintaining the six month interval between launches on which our operations in the Apollo program are now based. However, we will not launch Apollo 14 or any other flight unless and until we are confident that we have done everything necessary to eliminate the conditions that caused or contributed to the problems we encountered on Apollo 13 and are ready in all other respects. One of our prime concerns will be to maintain the efficiency and high standard of performance required of our launch and ground support teams during the extended periods of reduced activity entailed by the revised mission schedule and by the substantial cutbacks which have been made necessary by the overall reductions in the nation's space activities.

It is too early to present to you our detailed estimates of the costs and budgetary impact of the spacecraft modifications and program changes that we are making. Our best current estimate is that the modifications and changes related to the actions resulting from the Apollo 13 accident will be in the range of \$10 to \$15 million of increased costs, which we plan to handle within our total Apollo budget.

Before turning to Mr. Myers and Dr. Petrone, I would like to comment briefly on the lessons to be learned from Apollo 13. The Review Board found "that the accident was not the result of a chance malfunction in a statistical sense, but rather resulted from an unusual combination of mistakes, coupled with a somewhat deficient and unforgiving design." The presence of inadequate thermostatic switches in the heater circuits of the oxygen tanks, the loose fill tube assembly probably caused by a build-up of "worse case" tolerances and the "shelf dropping" incident, the improvised detanking procedure employed in preparing for launch, and the damaged Teflon-insulated fan motor wiring caused by overheating which later provided the ignition spark -- together all of these elements combined to cause the accident. In the absence of any one of these links in the chain of events, oxygen bottle number two would not have failed.

NASA's actions in response to the Board's recommendations will, in my view, avoid those specific things which led or contributed to the Apollo 13 accident; and the reviews and research we have undertaken will help us avoid future potential hazards throughout our programs. But in a larger context, we at NASA must be concerned with the fact that despite the rigorous management controls in effect and, from all the evidence, adhered to, a hazardous condition existed that was not identified and corrected. In fact, the presence of the inadequate thermostatic switches in the tank and the resultant baking of the wires at temperatures as high as 1000°F during detanking were not discovered until actual full scale tests were conducted for the Review Board in which wires were damaged, leading to a re-examination of the data recorded at KSC during the detanking and the switch specifications.

With regard to our contracts with North American Rockwell and Grumman for the spacecraft involved in the Apollo 13 mission, we have underway a review of the incentive provisions in their contracts to determine what steps should be taken by NASA in light of the accident. In accordance with our contract with North American Rockwell we will take the Service Module oxygen system failure into account in determining the amount of

the 1970 award fees to be paid. That fee will be determined in view of all activities during 1970, and thus will be based not only on the Apollo 13 accident but also on the effectiveness of the redesign and rebuilding activities during the months following the accident in preparation for Apollo 14.

In the case of the Grumman Lunar Module contract the fee provisions are phrased only in terms of performance during an actual lunar landing mission. However, since in performing as it did in the "lifeboat" mode the Lunar Module "Aquarius" clearly demonstrated its ability to have successfully performed most of the operations of an actual landing, we are performing a technical assessment of the Apollo 13 mission as it was flown to establish what portion of the performance was demonstrated and therefore what portion of the incentive fee should be paid.

In a program as large and complex as Apollo, involving thousands of people throughout the country, we must obviously depend on a rigorous documentation system to record and convey program management information. What we must always guard against, however, is the possibility of permitting this flow of careful documentation to substitute for the meaningful exchange of information. No matter how thorough and careful we are, we

ultimately depend on incisive and informed problem analysis by competent people who make the key decisions on the basis of their thorough understanding of the underlying actualities which are recorded in the documentation.

We cannot in the case of Apollo 13 point to one individual or group of individuals or organization and say that they caused the accident. Nor have we or the Review Board been able to formulate -- even with all the advantages of hindsight -- a procedure which, had it been in effect for Apollo 13, would have guaranteed that such an accident could never happen. The excellent recommendations of the Board in the areas of management and procedures can further strengthen Apollo and other NASA programs. But in the last analysis, we must depend upon the thoroughness and detailed understanding of all those in responsible positions in the NASA-industry hierarchy throughout every phase of design, manufacture, test and flight operations. I have the utmost confidence that the NASA team can fix the Apollo 13 problem and strengthen its operations to minimize the chances of future problems. We realize, however -- and the Members of this Committee realize -- that the exploration of space is a demanding and hazardous enterprise in which man is probing the unknown. NASA men and women are doing many things for the first time. Any

deficiencies in our ability to look ahead and foresee difficulties, any inattention to detail will be exposed in the harsh environments in which our work is tested. In my opinion, no finer or more dedicated group of people has ever worked together more effectively than this nation's space team, and I am confident of their continuing future success.

Mr. Chairman, this concludes my statement, and I would now like to ask Mr. Myers and Dr. Petrone to summarize in detail for you our proposed actions in response to the recommendations of the Apollo 13 Review Board.